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**A PROPOSAL FOR  
A NAVY TECHNOLOGICAL FORECAST  
PART 1 - SUMMARY REPORT**

**Report of the  
NAVY TECHNOLOGICAL FORECASTING  
STUDY GROUP  
to  
THE CHIEF OF NAVAL DEVELOPMENT**

May 1, 1966



OCT 1966  
*[Signature]*

**Headquarters, Naval Material Command  
Department of the Navy  
Washington, D.C.**

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## Navy Technological Forecasting

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The Chiefs of Naval Research and Development appointed an ad hoc group of eight persons in May 1965 from as many naval activities to look into the needs for a formal technological forecast. This forecast would be a document which would show the projected knowledge, abilities, and technical accomplishments of the entire Navy RDT&E effort over a forthcoming 20-year period. The group met over a period of six weeks, visited several RDT&E organizations in and out of Navy, and then issued a report ("Study by Ad Hoc Group on Navy Technological Forecasting," 15 June 1965) recommending that a technological forecast for the Navy would indeed be a very useful aid for its long-range planning effort.

As a follow-up, then, on the above recommendation, a Navy Technological Forecasting Study Group was established by the Chief of Naval Development in November 1965 to formulate a plan for a Navy technological forecast. This Group, identified on the facing page, performed within the mission of the Advanced Concepts Branch, Exploratory Development Division, Headquarters, Naval Material Command. The members met for six months, consulted with numerous individuals, visited a number of installations in industry as well as within the government complex, and arrived at the unanimous decision that a formal forecast for the Navy and Marine Corps would be beneficial and worthy of the effort. A proposed method of conducting a forecast was developed as well as a means for its implementation.

Results of this six-month study by the Navy Technological Forecasting Study Group are presented concisely herein, in Part 1 of the Group's report. The preparation of a Navy Technological Forecast is recommended, the nature and utility of such an effort are described, and a procedure for its accomplishment is presented.

Part 2 of this report contains much detailed supporting material, sample forecasts, methodologies, and possible categorizations.

The Group would like to express its appreciation to the many individuals in the Department of the Navy (Office of the Chief of Naval Operations; Office of the Commandant of the Marine Corps; Headquarters, Naval Material Command; Naval Systems Commands; Bureaus, Offices, and Laboratories), the Department of the Army, Department of the Air Force, other government agencies, and industry who gave freely of their knowledge and time during the course of this study.

In particular, the Group would like to express its appreciation to the following members of its Advisory Group:

Dr. R. O. Burns, Director, Technical Analysis and Advisory Group, Office of the Chief of Naval Operations

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Many knowledgeable persons from various naval laboratories worked with the Navy Technological Forecasting Study Group during the period 6 - 16 December 1965. Their assistance in developing forecasting philosophy and in preparing forecast samples is greatly appreciated. These persons are:

Mr. Kirk Abbey, Navy Electronics Laboratory

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The Group would also like to express its appreciation to Mrs. S. M. Boyce of the Headquarters, Naval Material Command for her outstanding administrative and secretarial support of the study and for her painstaking attention to organizational detail in preparing the manuscript of this report.

## CONTENTS

Preface	i
INTRODUCTION	1
BACKGROUND	1
NAVY TECHNOLOGICAL FORECAST (NTF)	1
MANAGEMENT STRUCTURE FOR PREPARATION OF THE NTF	3
SUGGESTED FORECAST FORMAT	4
ITEMS OF TECHNOLOGY TO BE INCLUDED	5
METHODS OF DERIVING THE FORECAST	5
PROPOSED UTILITY OF THE NTF	6
INTERSERVICE FORECASTING	7
SUMMARY	7

## A PROPOSAL FOR A NAVY TECHNOLOGICAL FORECAST

### PART I - SUMMARY REPORT

#### INTRODUCTION

Effective planning of the Navy Research, Development, Test and Evaluation Program, to meet both short-term and long-range goals for the Fleet, includes the ability to project the course of technology into the future. Intuitive prediction of technological capability is common in routine planning activity in the Navy technical community, but a formalized coordinated forecast is not yet practiced. This report addresses itself to managing a proposed formal technological forecast, suggesting a format and methodology for developing a forecast, and indicating the potential utility of the product.

#### BACKGROUND

During the past two years several informal meetings were held by representatives of the Chiefs of Naval Operations, Material, Development, and Research to discuss the desirability of producing a formal Navy Technological Forecast. An ad hoc group composed of various Navy representatives was established by the Chiefs of Naval Research and Development to conduct investigative studies related to technological forecasting. The group concluded that the Navy would realize definite benefits at all management levels by the application of meaningful forecasts in planning research, technology, and operational systems development programs.

The studies disclosed the existence of technological forecasts prepared by other government agencies and industry. The Air Force's "Project Forecast," conducted in 1963, and the Army's "Long Range Technological Forecast," initiated in 1962, were of particular interest because they contained forecasts of technology of concern to the Navy. The degree to which the Air Force and Army utilized their respective forecasts as guides in their long-range planning was of particular interest in light of a possible Navy program. The benefits of the use of forecasts when planning R&D programs were also demonstrated by industrial concerns working on Navy projects.

The group recommended that the Navy conduct a Technological Forecast and that a more detailed study be made of the techniques, implementation, and utility of forecasting. The recommendations of this ad hoc group were accepted by the Chiefs of Naval Research and Development, and then a second working group - the Navy Technological Forecasting Study Group - was formed to establish a proposal for Navy Technological Forecasting, and this proposal is now submitted.

#### NAVY TECHNOLOGICAL FORECAST (NTF)

##### Definition

A technological forecast is the prediction of a technical achievement, and its associated confidence level, in a given time frame for a specified level of support. A technological forecast is a tool for planning and decision-making, but it is not a plan. A more detailed discussion as to the differentiation between forecasting and planning and where forecasting fits into the research and development planning cycle is discussed in Part 2 of this report.

## Description

As proposed, the Navy Technological Forecast would consist of a loose-leaf document in three parts, containing prognostications of individual pertinent advances, capabilities, limitations, or developments which the naval scientific and technological community can be predictably assured of having available during a forthcoming 20-year period. This document would describe scientific knowledge, capabilities in technology, and examples of subsystems, components, or systems which science and technology should expect to produce during this period. The NTF would be divided into three parts for convenience of the user.

PART I - Scientific Opportunities. Should contain the significant projections of research in the physical, engineering, environmental, and life sciences normally associated with the RDT&E 6.1 planning categories. The advances and limitations in scientific research defined in Naval Research Requirements which are relevant to future technological capabilities of the Navy would be discussed.

PART II - Technological Capabilities. Should contain the significant projections of applied research and development which normally are included in RDT&E 6.2 planning categories. This section of the forecast should cover a broad spectrum of research and development ranging from basic technologies (e.g., power conversion) to functional capabilities (e.g., deep ocean technology).

PART III - Probable Systems Options. Should rely heavily on the first two parts to suggest examples of subsystems or systems which could be developed if the capabilities described in Parts I and II above are achieved. The options to be included should be supportable by realistic projected capabilities.

## Technology Needs Identification Studies

As part of the Navy Technological Forecast, a series of Technology Needs Identification Studies (TENIS) is proposed similar in general outline to Technical Workshops, but with the prime purpose being the identification of critical areas. While this TENIS approach is essentially a planning procedure designed to fulfill specific needs, it provides a valuable insight into supporting RDT&E capabilities and deficiencies. In each study, mission needs, which are identified by cognizant authority and translated into associated functional capabilities and corresponding technical requirements, are forecast in detail. These forecasts-in-depth are based on a projection of the expected technological developments and applications during the forecast period and are conducted prior to the Workshop. The Workshops would also utilize the principal technological forecast information that applies to that specific area. System design parameters are defined and an analysis is made of the supporting research and development effort required to achieve the operational objectives.

## Objective

A usable NTF will provide the Navy long-range planners at all echelons of the RDT&E organization with an updated summary of the state of Navy science and technology during a 20-year period into the future. These predictions - either advances or limitations - will provide ideas and building blocks in interrelated fields of technology for assisting the decision maker in planning his long-range programs for development of future operational systems. The Navy planner must be knowledgeable in a variety of technical fields, and effective planning incorporates the newest or most promising discoveries or developments in many correlated disciplines. The technological forecast will assist in providing this cross-fertilization.

The scope of the NTF will be constrained in most cases to new "Research and Development." In the interest of brevity, the R&D programs appearing on Forms DD 1498 or on-going funded programs to be completed in an immediately forthcoming three-year period or less will generally be excluded from the forecasts. The basic need is to project the current capabilities for a "look into the future."

#### MANAGEMENT STRUCTURE FOR PREPARATION OF THE NTF

##### Primary Responsibility

Navy R&D laboratories, with assistance from academic organizations and industrial concerns via the laboratories' normal associations, should be assigned primary responsibility for gathering the technical data and information needed to prepare the individual forecast items for the overall NTF.

##### Supporting Responsibility

Representatives of the Chief of Naval Research and the Chief of Naval Development should share the supporting responsibility for assigning areas of Navy technology to be forecast, providing and managing guidelines, and preparing the overall NTF. The Chief of Naval Research should be responsible for Part I and the Chief of Naval Development for Parts II and III.

##### Coordinating Responsibility

The Chief of Naval Development should assume the coordinating responsibility for the entire NTF as well as the final documentation of the integrated product. To aid him in this effort, he should have a small group, designated the Technological Forecasting Group (TFG), which should have the responsibility for coordinating the total effort under his primary direction.

##### Responsibilities of the TFG

1. To recommend areas of R&D to be forecast by the Office of Naval Research, Naval Systems Commands, Offices, Bureaus, and Laboratories.
2. To coordinate all efforts with ONR, Systems Commands, Offices, Bureaus, and Laboratories in order to generate the NTF.
3. To coordinate the NTF with the Marine Corps.
4. To collect, review, edit, publish, distribute, and update the NTF.
5. To contact the Army and Air Force forecast groups, as necessary.

##### Responsibilities of the Chief of Naval Research, Within His Area

1. To update the forecast categories.
2. To delegate responsibility for forecasting to appropriate personnel.

3. To select significant areas to be included in the forecast.
4. To review and coordinate forecast materials.
5. To coordinate Part I with the TFG.

#### Responsibilities of the Chief of Naval Development, Within His Area

1. To review and identify significant categories to be forecast.
2. To delegate responsibility for forecasting to appropriate organizations.
3. To review and coordinate forecast materials.
4. To coordinate Parts II and III with the TFG.

#### Responsibilities of the Systems Commands, Bureaus, Offices and Laboratories

1. To identify significant categories to be forecast after coordination with the TFG.
2. To prepare forecasts.
3. To coordinate with other Navy organizations, other services, industry, and academic communities for assistance in preparing forecasts.
4. To update forecasts after coordination with the TFG.

#### SUGGESTED FORECAST FORMAT

The contents of an individual forecast presentation should be flexible - largely determined jointly by the personnel preparing the Forecast and the TFG. Each forecast item, however, should be covered by the information described below.

1. Background including present status - The background should briefly highlight the evolution of the technology being forecast with emphasis on relevance to Navy technological needs. The present status should present the state-of-the-art of the category as a basis for forecast projections.

2. New capability or technical approach - The proposed functions, characteristics, or concepts of any new item should be presented including limitations which might exist. Where appropriate, tabular or graphical presentations should be used to show merits of competing items. Functional diagrams should be included in describing the technical approach.

3. Forecast - The forecast should graphically display a projection of anticipated advances of the item as a function of time up to 20 years. This projection should be a quantitative expression of achievable parametric limits, where possible showing the level of confidence in the validity of the projection. Supporting and qualifying narration should be minimized.

4. Potential significance to the Navy - Where appropriate, the value of the items forecast should be appraised in light of Navy relevance.

5. References - For the convenience of the user who may want to obtain further information, the reference section should list associated R&D organizations making important contributions, names of outstanding experts, and references to reports or literature supporting the forecast material.

#### ITEMS OF TECHNOLOGY TO BE INCLUDED

The initial items to be included in the NTF should be limited to the most significant from the standpoint of relevance to Navy needs. They should be determined by the TFG and the organizations doing the forecasting, using the following general categories as guides:

##### Science and Engineering

Physical Sciences  
Engineering Sciences  
Environmental Sciences  
Life Sciences

##### Subsystems/Components/Technology

Vehicles/Installations  
Weaponry/Armament  
Surveillance/Target Acquisitions/Navigation  
Communications/Command & Control  
Countermeasures  
Logistics  
Target Environment  
Power Conversion

##### Systems

Strategic  
Tactical  
Amphibious  
Antisubmarine  
Fleet Defense  
Space

#### METHODS OF DERIVING THE FORECAST

The techniques for projecting technology into the future are relatively new and untried. The most obvious and perhaps the easiest method is to assume that changes occurring in the past will continue into the future provided there are no disturbances to alter these events. Most intuitive forecasts of progress are probably based on this relatively inaccurate extrapolation technique. The forecast is accomplished by plotting past experience, trends, or accomplishments as a function of time and extrapolating the curve into the future. The extrapolation is influenced by known or expected capabilities, limitations, or factors which affect the projection. Typical growth curves often assume an exponential character when plotted as a function of time. The farther the forecast is projected into the future, the greater the possibility that the curve is inaccurate.

Over the period of the life of a technical development, progress as a function of time often assumes an S-shaped curve. The "growth" of a technology is analogous to the growth usually witnessed in biological phenomena. The initial advance is slow during the learning

or early growth period. The medium stages accelerate more rapidly with a consequent exponential growth. At later stages of advancement, during maturity, the effects of limitation prevent the rapid acceleration and the progress curve levels off.

Frequently, if progress in successive related developments is plotted as a function of time, the overall growth curve for all the developments assumes an exponential curve. Although each step in the overall progress may have the typical S-curve, breakthroughs or new "ideas" occur which start another increase in progress as the old "idea" loses its effect. The synthesis of several fields of progress, each occurring at different intervals, may result in an exponential advance for a functional capability.

The trend of a technical parameter which is complex and difficult to predict by itself may sometimes be more easily expressed as a result of a relationship with one or more other trends. In this case the projection of an unknown is made on the basis of known related variables.

#### PROPOSED UTILITY OF THE NTF

##### Research and Development Studies

The NTF should indicate the expected advancements as well as limitations in the Navy-oriented science and technology areas and the probable systems options conceived from these advances. It is suggested that this collection of future potential capabilities be utilized as inputs to comprehensive R&D studies which are frequently made by Navy personnel when specific operational or developmental needs arise.

##### Research and Development Planning

Representatives from the following organizations expressed particular needs for a technological forecast for use as guidelines in R&D planning.

1. Office of Commandant of the Marine Corps
2. Office of the Chief of Naval Operations
3. Headquarters, Naval Material Command
4. Office of Naval Research
5. Ordnance Systems Command
6. Air Systems Command
7. Ship Systems Command

A quality concise Forecast of pertinent significant future capabilities in science, technology, and development of systems should be an asset to managers justifying funding requests and planning R&D programs. The Forecast can assist in establishing the scientific and technological base on which Naval Research Requirements and Goals for Exploratory Development would be formulated.

##### Other Applications

A meaningful forecast of technology would find utility in the following endeavors:

1. Making a technically sound evaluation of the enemy threat in the 20-year forecast period which produces the base necessary to evolve general requirements (complete interpretation, understanding, and dissemination of the threat is beyond the responsibility of the Forecast).

2. Defining general requirements to meet and/or exceed the projected threat of the 20-year forecast period.
3. Establishing U.S. technological capabilities through the 20-year forecast period and specifying in general the time phasing and steps of progression to reach defined milestones.
4. Identifying the vital technological parameters at performance levels in each component or concept area; determining the level of technology that will be required in these parameters for each projected operational capability and the confidence with which it is expected that these levels will be reached with program funding at accelerated funding levels; identifying any parameters in which there are serious gaps between the required and programmed level capability.
5. Outlining a matrix for technology/capability which can be refined and used as a base for defining possible systems after general requirements for the enemy threat are defined.
6. Examining the extent of interdependence of the various technical disciplines and assessing the manner in which advances in one technical area will affect the advances needed by and capable of achievement in one or more related technical areas.
7. Identifying critical technologies including promising technology of intuitively high payoffs not directly responsive to the threat and resource levels required to support these technologies.
8. Identifying advanced technologies which will enhance capability and effectiveness in fulfilling mission capabilities.
9. Providing inputs for the definition of the impact of limits and restrictions imposed by policy on technologies.

#### INTERSERVICE FORECASTING

The Navy Technological Forecasting Study Group held many discussions with Marine Corps, Army, and Air Force representatives. Long lines of interservice interests of technological forecasting both from a content and utility point of view. It became quite apparent that the forecasting interests of the services are very close in the more fundamental research areas, where scientific disciplines are being explored. But these interests become more diverse as forecast topics change from research and development items to engineering development and operational utility programs. The Group recommends that the close working relationship established among the services during the study effort be maintained.

#### SUMMARY

1. The Navy Technological Forecasting Study Group recommends that the Navy should initiate a formal Navy Technological Forecast which could benefit long-range planners at all echelons.
2. The scope of work should include significant projected capabilities in all areas of science and technology relevant to Navy activities, and as a first effort to specific Navy needs.

3. The initial Forecast should be constrained to a few vital areas of research and development in order to allow the organizations implementing the effort to "learn" how to forecast effectively. The number of items included should increase to include all significant areas of Navy science and technology as the success of the initial effort dictates.

4. The NTF should be divided for convenience of potential users into three parts: Scientific Opportunities, Technological Capabilities, and Probable Systems Options.

5. The Chief of Naval Research should have administrative responsibility for Part I (Scientific Opportunities) of the Forecast. The administrative responsibility for Parts II and III (Technological Capabilities and Probable Systems Options, respectively) should be the responsibility of the Chief of Naval Development. The staff group of the Chief of Naval Development within Headquarters, Naval Material Command should have responsibility for coordinating and integrating the Forecast into a single document. A Technological Forecasting Group (TFG) should be established to effect this coordination of the overall effort.

6. The categories of science and technology to be included in the Forecast should be determined by the forecasting organizations in conjunction with the TFG.

7. Although the Navy Commands, Bureaus, Offices, and Laboratories will have prime responsibility for preparation of the inputs to the Forecast, it is expected that the scientific and technical projections will represent the latest relevant thinking of the academic and industrial research and development communities.

8. Close cooperation between the Navy, Marine Corps, Army, and Air Force in forecasting should continue in all areas of mutual interest. Coordination between services is essential to assure compatibility in quantitative data. Uniform methodology, if it can be accomplished, can be very helpful to the services utilizing each other's pertinent information.

9. Updating of the NTF should be a dynamic process as the need exists. A complete updating should be accomplished after approximately two to three years.

10. The NTF should include technology relevant to both the Navy Department and Marine Corps.

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<p>Part 1, Summary Report, presents in concise form the results of a six month study carried out by the Navy Technological Forecasting Study Group. The preparation of a Navy Technological Forecast is recommended. the nature and utility of such an effort are described, and a procedure for its accomplishment is briefly presented</p> <p>Part 2, Back-Up Report, presents much detailed supporting material, sample forecasts, methodologies, and possible categories. It is expected that the details covered will greatly aid those responsible for generating Navy Technological Forecasts</p>			

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